

A Multi-Axis Best Fit to the Collider Supersymmetry Search: The Aroma of Stops and Gluinos at the $\sqrt{s} = 7$ TeV LHC

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In *Profumo di SUSY*, we presented evidence that the CMS and ATLAS Collaborations may have already registered a handful of deftly camouflaged supersymmetry events at the LHC in the multijet channels. Here, we explore the prospect for corroboration of this suggestion from five additional CMS and ATLAS search strategies targeting the production of light stops and gluinos at lower jet counts, which variously depend on heavy flavor tagging and the inclusion or exclusion of associated leptons. The current operating phase of the $\sqrt{s} = 7$ TeV LHC is highly conducive to the production of gluinos and light stops, given the supersymmetric particle mass hierarchy $M(\tilde{t}_1) < M(\tilde{g}) < M(\tilde{q})$ that naturally evolves from the dynamics of the model named No-Scale \mathcal{F} - $SU(5)$ that we presently study. Moreover, some tension persists against the Standard Model data-driven and Monte-Carlo generated background predictions in certain LHC searches of this variety. We demonstrate that the $1\text{-}\sigma$ overlap of the allowed supersymmetric event production for these seven search methodologies roundly envelops the most favorable phenomenological subspace of \mathcal{F} - $SU(5)$, whilst handily generating a 125 GeV Higgs boson mass. In order to test the statistical significance of any correlations across the simulated \mathcal{F} - $SU(5)$ collider response in these seven search strategies, we implement a multi-axis χ^2 fitting procedure, yielding a best overall match in the vicinity of $M_{1/2} = 610$ GeV, corresponding to light stop and gluino masses of approximately 665 GeV and 830 GeV. Consequently, we suggest that No-Scale \mathcal{F} - $SU(5)$ is a better global fit to the studied LHC data than the SM alone, and moreover that its predictions appear to be meaningfully correlated with observed low-statistics excesses across a wide variety of specialized search strategies. We suspect that the already collected 5 fb^{-1} of integrated luminosity will be sufficient to either condense or disperse the delicate aroma of stops and gluinos that suffuses the early search.

PACS numbers: 11.10.Kk, 11.25.Mj, 11.25.-w, 12.60.Jv

I. INTRODUCTION

The Large Hadron Collider (LHC) at CERN has to date delivered an integrated luminosity of up to 5 fb^{-1} of proton-proton collisions at a center-of-mass beam energy of $\sqrt{s} = 7$ TeV, with a further 15 fb^{-1} anticipated during 2012, in tandem with an upgrade to $\sqrt{s} = 8$ TeV. The CMS and ATLAS Collaborations have analyzed the first $1\text{--}2\text{ fb}^{-1}$ of data in their search for signals of supersymmetry (SUSY), thus far revealing no significant excesses beyond the Standard Model (SM) expectations. The absence of any definitive signal has imposed severe constraints onto the viable parameter spaces of the baseline supersymmetric models, leading pessimists to question whether there is even a SUSY framework extant in nature to discover at all. Nevertheless, a few select search methodologies have exhibited curious indications of strain between the maximum reasonable expectation for the background and the number of observations in the data [1–5]. This begs the question of whether such tensions are mere statistical fluctuations, the inevitable “look elsewhere” styled distribution tails that become probable *somewhere* within an exhaustive search, or per-

haps rather early warning indicators of something much more significant yet to come. Given any reasonable likelihood that we *may* indeed be witnessing the commencement, in its earliest nascent phase, of a legitimate SUSY signal effervescing to the surface, then it becomes imperative to closely examine these particular search strategies in unison to uncover clues as to whether they might originate from a common underlying physics. Such a multi-axis study could imply a key connection not apparent from the individual searches in isolation, allowing for the directed *correlation* across independent selection spaces to statistically distinguish a signal from the noise. The demonstration of a specifically detailed supersymmetric model that can expose tendencies for high SUSY visibility in the appropriate searches, without damaging event overproduction in those cases where the observations are in stricter accord with the expected backgrounds, would suggestively hint that the currently observed stresses might represent an authentic physical correlation after all.

In a previous work entitled *Profumo di SUSY* [6], we investigated a pair of early single inverse femtobarn LHC reports from CMS [1] and ATLAS [4], where data ob-

servations for events with ultra-high jet multiplicities, minimally seven to nine, could be readily extracted. In the time frame preceding release of the CMS and ATLAS reports [1, 4], we had been strongly advocating for close scrutiny of precisely these sort of events [7–10], following a realization that the unique spectrum of our favored SUSY construction, and in particular its rather light stop squark \tilde{t}_1 and gluino \tilde{g} , would lead to a strong and distinctive signal in these particular channels. Consequently, we were gratified that an initial inquiry into such events could be undertaken at the LHC, and buoyed by the observation of scant, yet nonetheless tantalizing, excesses in events with ≥ 7 –9 jets. We thus undertook a carefully detailed study in Ref. [6]. During the intermission between those early CMS and ATLAS reports [1, 4] and the present time frame, numerous parallel high luminosity studies from CMS and ATLAS have appeared to compliment those discriminated by jet count. In the present work, we thus broaden our horizon to encompass the wider panorama of search strategies squarely directed at the detection of pair-produced gluinos and light stops, including light stops transpiring from gluino mediated decays. This is a calculated augmentation, given that our model is auspiciously predisposed to the production of gluinos and light stops in the present running phase of the LHC. Moreover, it facilitates precisely the sort of cross-correlation between independent experimental signatures previously described. This will be quantified in the present work by application of a χ^2 statistical test in seven degrees of freedom. If the prior fleeting scent [6] of supersymmetry in the multijet data was corporeal, then that same aroma should linger also in certain of the wider stop and gluino searches; if it was a wishfully conjured mirage, then even the memory must fade in the cleansing light of new data.

II. THE NO-SCALE \mathcal{F} - $SU(5)$ MODEL

The context of our study on the correlation of light squark and gluino SUSY searches is a model named No-Scale \mathcal{F} - $SU(5)$ [6–20]. No-Scale \mathcal{F} - $SU(5)$ is defined by the convergence of the \mathcal{F} -lipped $SU(5)$ [21–23] grand unified theory (GUT), two pairs of hypothetical TeV scale vector-like supersymmetric multiplets (dubbed *flippons*) of mass M_V with origins in local \mathcal{F} -theory [24–28] model building, and the dynamically established boundary conditions of No-Scale Supergravity [29–33]. This construction inherits all of the most beneficial phenomenology of the flipped $SU(5) \times U(1)_X$ [21–23, 34] gauge group structure, as well as all of the valuable theoretical motivation of No-Scale Supergravity [29–33]. A substantially more detailed theoretical treatment of the model under analysis is available in the cited references, including a rather thorough summary in the Appendix of Ref. [8].

Since mass degenerate superpartners for the known SM fields are not observed, SUSY must itself be broken around the TeV scale. In the Constrained Minimal

Supersymmetric Standard Model (CMSSM) and minimal supergravities (mSUGRA) [35], this occurs first in a hidden sector, and the secondary propagation by gravitational interactions into the observable sector is parameterized by universal SUSY-breaking “soft terms” which include the gaugino mass $M_{1/2}$, scalar mass M_0 and the trilinear coupling A . The ratio of the low energy Higgs vacuum expectation values (VEVs) $\tan\beta$, and the sign of the SUSY-preserving Higgs bilinear mass term μ are also undetermined, while the magnitude of the μ term and its bilinear soft term B_μ are determined by the Z -boson mass M_Z and $\tan\beta$ after electroweak symmetry breaking (EWSB). In the simplest No-Scale scenario, $M_0=A=B_\mu=0$ at the unification boundary, while the complete collection of low energy SUSY breaking soft-terms evolve down with a single non-zero parameter $M_{1/2}$. Consequently, the particle spectrum will be proportional to $M_{1/2}$ at leading order, rendering the bulk “internal” physical properties invariant under an overall rescaling. The matching condition between the low-energy value of B_μ that is demanded by EWSB and the high-energy $B_\mu = 0$ boundary is notoriously difficult to reconcile under the renormalization group equation (RGE) running. The present solution relies on modifications to the β -function coefficients that are generated by radiative loops containing the vector-like *flippon* multiplets. By coupling to the Higgs boson, the *flippons* will moreover have an impact on the Higgs boson mass m_h [36–38], resulting in a 3-4 GeV upward shift in m_h , handily generating a Higgs mass of 124-126 GeV [20] that is in fine accord with the recent ATLAS and CMS reports [39, 40].

Pertinent to the present work, we have previously demonstrated the range of the \mathcal{F} - $SU(5)$ model space that is adherent to a set of firm “bare-minimal” phenomenological constraints [15], including consistency with the world average top-quark mass m_t [41], the dynamically established boundary conditions of No-Scale supergravity, radiative electroweak symmetry breaking, the centrally observed WMAP7 CDM relic density [42], and precision LEP constraints on the lightest CP-even Higgs boson m_h [43, 44] and other light SUSY chargino and neutralino mass content. We have moreover established a highly constrained subspace, dubbed the *Golden Strip* [12, 15, 18], that is noteworthy for its capacity to additionally conform to the phenomenological limits on rare processes that are established by measurement of the muon anomalous magnetic moment $(g_\mu - 2)/2$ and the branching ratios of the flavor-changing neutral current decays $b \rightarrow s\gamma$ and $B_S^0 \rightarrow \mu^+\mu^-$. A similarly favorable *Silver Strip* slightly relaxes the constraints imposed by $(g_\mu - 2)$.

III. \mathcal{F} - $SU(5)$ STOPS AND GLUINOS

Production of the light stop \tilde{t}_1 and gluino \tilde{g} at the early LHC in the first 5 fb^{-1} of integrated luminosity and nat-

urally accounting for a 125 GeV Higgs boson tend to be mutually exclusive goals for the traditional MSSM constructions. In particular, the mechanism for elevation of the Higgs mass will typically correspond to squark and gluino masses which are far too heavy to have yet crept above the SM background for the initial $\sqrt{s} = 7$ TeV operating phase of the LHC. For instance, it has been suggested that in the CMSSM and mSUGRA, the only viable remnant of solution space that has thus far survived the rapidly encroaching LHC constraints while delivering a 125 GeV Higgs boson mass requires a super-heavy scalar mass m_0 of 10–20 TeV [45], which is well beyond reach of the LHC operating energy, both currently and into the future. The additional contributions from the vector-like *flippons* are the key to differentiating \mathcal{F} - $SU(5)$ from the CMSSM and mSUGRA. The *flippon* loops allow a 125 GeV Higgs boson in conjunction with a light TeV-scale SUSY spectrum. In contrast, the CMSSM and mSUGRA require very large values of the trilinear A-term, which pushes m_0 to very large values, such that the extremely massive stop and sbottom squark masses lead to severe electroweak fine-tuning [45]. No-Scale \mathcal{F} - $SU(5)$ takes advantage of the same strongness of the Higgs to top quark coupling that provides the primary lifting of the SUSY Higgs mass to generate a hierarchically light partner stop in the SUSY mass-splitting. However, this rather generic mechanism is not in itself enough. The model further leverages the same vector-like multiplets which provide the secondary Higgs mass perturbation to flatten the RGE running of universal color-charged gaugino mass M_3 , blocking the standard logarithmic enhancement of the gluino mass at low energies, and producing the distinctive mass ordering $M(\tilde{t}_1) < M(\tilde{g}) < M(\tilde{q})$ of a light stop and gluino, both substantially lighter than all other squarks. The stability of this distinctive mass hierarchy is manifest across the entire model space, a hierarchy that is not precisely replicated in any MSSM constructions of which we are aware.

Indeed, it is specifically because the light stop \tilde{t}_1 and gluino \tilde{g} are less massive than the heavier bottom squarks \tilde{b}_1 and \tilde{b}_2 and the first and second generation left and right squarks \tilde{q}_R and \tilde{q}_L that we are afforded a uniquely distinctive test signature for \mathcal{F} - $SU(5)$ at the LHC. This spectrum generates a characteristic event topology starting from the pair production of heavy squarks \tilde{q} and/or gluinos \tilde{g} in the initial hard scattering process, with each squark likely to yield a quark-gluino pair $\tilde{q} \rightarrow q\tilde{g}$ in the cascade decay. The gluino will tend to decay via QCD to a typical 2-jet final state as $\tilde{g} \rightarrow q\bar{q}\tilde{\chi}_1^0$, though at an atypically low 60% branching ratio. The weakly interacting lightest neutralino $\tilde{\chi}_1^0$ escapes the detector unseen, leaving only an imprint of missing energy. This leaves allowance for the production of light stops through gluino decays $\tilde{g} \rightarrow \tilde{t}_1\bar{t}$ at a relatively high rate of 40%, where the light stops decay as $\tilde{t}_1 \rightarrow t\tilde{\chi}_1^0$ at 58% and as $\tilde{t}_1 \rightarrow b\tilde{\chi}_1^\pm$ at 32%. We note that the intermediate light stop may tend to be off shell, particularly for the lighter \mathcal{F} - $SU(5)$ spectra, below a gaugino mass $M_{1/2}$ of about 700 GeV.

The repercussions of these final states are two-fold. Firstly, it is expected that each gluino will produce *at least* four hard jets 40% of the time. Processes such as this may then consistently exhibit a net product of eight or more hard jets emergent from a single squark-squark, squark-gluino, or gluino-gluino pair production event. When the further process of jet fragmentation is allowed after the primary hard scattering events and the sequential cascade decay chain, this will ultimately result in a spectacular signal of ultra-high multiplicity final state events. Events with very high multiplicity jets have received little study in legacy experiments such as LEP and those at the Tevatron, though fortunately such analyses are now beginning to receive more than just sporadic attention at LHC. Recognizing the prospect of a conveniently encoded SUSY signal within such multijet events, we optimistically anticipate a near-term expansion search horizon in the high multiplicity regime.

A second impact of the \mathcal{F} - $SU(5)$ final states could be discovery of the light stop and gluino production itself. Considering the high production rate of gluino mediated light stops at 40%, those SUSY searches currently focused more intently on the $\tilde{g} \rightarrow \tilde{t}_1 t$, $\tilde{t}_1 \rightarrow b\tilde{\chi}_1^\pm$, and $\tilde{t}_1 \rightarrow t\tilde{\chi}_1^0$ channels may also expect to reap tangible benefits within this construction. In contrast to the relatively unexplored region of ultra-high jet multiplicities, searches more directly focused on gluino and light stop production are gaining maturity. These searches typically concentrate on final product states of b-jets (heavy flavor tagging) and leptons, along with smaller multiplicities of jets. Thus, we would not be surprised at all if an initial conclusive signal discovery emanated from these search methodologies. In fact, a dual signal emergent in gluino and stop production search strategies and in the ultra-high jet multiplicity events will be highly suggestive of \mathcal{F} - $SU(5)$ origins.

A further consequence of the accessible mass of the \mathcal{F} - $SU(5)$ light stop in the present operational phase of the LHC is the more pronounced direct production cross-section of the light stops from the hard scattering event. An inspection of the direct production cross-sections for squarks, gluinos, and light stops, along with the branching ratios, yields an expectation that about 15-20% of light stop production at the LHC in an \mathcal{F} - $SU(5)$ framework would be pair-production directly from the hard scattering collision. This is in contrast to other MSSM based constructions, where it is not uncommon for less than 1% of all light stops to be produced directly.

IV. THE LHC SUSY SEARCH

We now focus on seven ongoing LHC SUSY search strategies, of which five are substantially orthogonal in construction, that are sensitive to the \mathcal{F} - $SU(5)$ final states comprised of stops and gluinos decaying into some quantity of jets. Each one of these seven event selection methodologies exhibits at least slight positive strain

against the expectation for the SM background, a correlation that we shall demonstrate may not be coincidental. First, we offer a concise summary of each search strategy, then present the \mathcal{F} - $SU(5)$ contribution to each in Section VI, followed by a multi-axis χ^2 best fit against the full contingent of selection strategies in Section VII.

A. CMS Purely Hadronic Large Jet Multiplicities

This search is detailed in Ref. [1] and based upon a data sample of 1.1 fb^{-1} . All hadronic events with high p_T are discriminated by jet count, allowing for smooth extrapolation of events with very high jet multiplicities. The primary cuts are $H_T \geq 375 \text{ GeV}$, $E_T^{Miss} \geq 100 \text{ GeV}$, and $p_T > 50 \text{ GeV}$. We use the data sample with no α_T cut, which we have argued is actively biased against events with high multiplicities of jets [8]. We apply a further cut on jet count, retaining only those events with greater than or equal to nine jets. This search strategy is very favorable for exposing an \mathcal{F} - $SU(5)$ signal emanating from the sequential cascade decays of gluinos, squarks, and light stops to many jets. We have studied this search methodology in some detail in Ref. [6], and we now reprise that analysis with the intent of revealing any potentially hidden correlations with a much more broad sampling of contemporary LHC SUSY searches.

B. ATLAS Large Jet Multiplicities

The fine points for this search can be found in Ref. [4], in a study based upon 1.34 fb^{-1} of data. Here again, all events are segregated by jet count, permitting a straightforward extraction of events of all high multiplicity jet counts. Additionally, four key combinations of the jet count and transverse momentum p_T per jet thresholds are isolated in the tables for detailed study. We choose to keep only those events with at least 7 jets with $p_T > 80 \text{ GeV}$ for the case of $E_T^{Miss}/\sqrt{H_T} > 3.5$. As with the preceding SUSY search, this scenario will also be sensitive to the large \mathcal{F} - $SU(5)$ multijet final states. Likewise, we invested much detail in the analysis of this search strategy in Ref. [6], which we again carry over in the interest of exposing correlations within a more comprehensive range of possible channels for a SUSY discovery. The present incarnation of this search does differ with our prior report in one regard: we have opted in this work to employ the cone jet finding algorithm provided with PGS4 [46] rather than the k_t jet alternative.

C. ATLAS B-jets plus Lepton

The first undertaking of this ATLAS search strategy is defined in Ref. [2], employing a data sample of 1.03 fb^{-1} . The requirement here is at least four jets, a minimum of one b-jet, precisely one lepton, $p_T > 50 \text{ GeV}$ for all jets,

$E_T^{Miss} > 80 \text{ GeV}$, and $M_{eff} > 600 \text{ GeV}$. In our analysis here, we choose to harness the data-driven background findings. This strategy will be sensitive to large cross-sections of $\tilde{g}\tilde{g}$ production with large branching ratios for $\tilde{g} \rightarrow \tilde{t}_1 t$, as is expected in \mathcal{F} - $SU(5)$. Therefore, this strategy is very sensitive to gluino-mediated light stop production in \mathcal{F} - $SU(5)$, which is currently in a very favorable production phase at the LHC. However, we must note that the simplified model interpretation in Ref. [2] assumes a 100% branching ratio for $\tilde{t}_1 \rightarrow b\tilde{\chi}_1^\pm$, whereas the \mathcal{F} - $SU(5)$ branching ratio is only 32%. Thus, we caution that the \mathcal{F} - $SU(5)$ spectra may be misrepresented in the generic imposition of model limits.

D. ATLAS B-jets plus Lepton SR1-D

The ATLAS B-jets plus Lepton search in the previous subsection has been updated to an extent in Ref. [47] for 2.05 fb^{-1} . While still implementing the same pre-selection cuts as Ref. [2], the cuts on the leading jet p_T and M_{eff} have been altered, in turn significantly affecting the surviving background sample, and possibly any embedded signal as well. Therefore, we consider the shift in the final results to be consequential enough to warrant an independent analysis of Refs. [2] and [47]. In Ref. [47], the two strategies of interest here are the SR1-D and SR1-E. In the case of SR1-D, the search parameters have been updated such that the p_T for the leading jet has been raised to $p_T > 60 \text{ GeV}$ and the cut on effective mass has been increased to $M_{eff} > 700 \text{ GeV}$.

E. ATLAS B-jets plus Lepton SR1-E

The additional SR1-E scenario of Ref. [2], over and above the further cuts implemented in SR1-D, has elevated the missing energy component to $E_T^{miss} > 200 \text{ GeV}$. In our analysis to follow in Section VI, we shall clearly discriminate between the three ATLAS B-jets plus Lepton cases due to the substantial impact that the re-tuned cuts have on the data sample. Each scenario will therefore illustrate a unique state of the SUSY discovery program.

F. ATLAS Purely Hadronic Events

This study is based upon the search methodology in Ref. [3], using a data sample of 1.04 fb^{-1} . We apply the “High Mass” cuts, consisting of at least four jets, $p_T > 80 \text{ GeV}$ ($p_T > 130 \text{ GeV}$ for the leading jet), no lepton, $E_T^{Miss} > 130 \text{ GeV}$, and $M_{eff} > 1100 \text{ GeV}$. The intent of the “High Mass” strategy is to extend a maximal reach into the SUSY mass spectrum. Sensitivity will be high for models with large cross-sections of pair-produced $\tilde{g}\tilde{g}$, $\tilde{g}\tilde{q}$, and $\tilde{q}\tilde{q}$, where $\tilde{q} \rightarrow q\tilde{\chi}_1^0$ and $\tilde{g} \rightarrow q\tilde{q}\tilde{\chi}_1^0$. As indicated earlier, the gluinos in \mathcal{F} - $SU(5)$ are lighter than all

squarks except the light stop, hence the $\tilde{q} \rightarrow q\tilde{g}$ channel will prevail more than 90% of the time for the \tilde{q}_R and two-thirds of the time for the \tilde{q}_L . Thus, the $\tilde{q} \rightarrow q\tilde{\chi}_1^0$ path is comparatively suppressed in $\mathcal{F}\text{-}SU(5)$. However, with the rate of gluino to jets at 60% for $\tilde{g} \rightarrow q\tilde{q}\tilde{\chi}_1^0$, this search should remain sensitive to the $\mathcal{F}\text{-}SU(5)$ gluino production. Since leptons are explicitly excluded, the QCD background here is expected to be troublesome. The implementation of the “High Mass” cuts certainly alleviate the QCD predicament to some degree, although the signal may also be diminished in scope as well.

G. CMS Jet-Z Balance

We employ the search of Ref. [5] here, which is based upon a data sample of 2.1 fb^{-1} . The JZB method concentrates on states containing a Z-boson, jets and missing energy. The advantage here is that the contribution from $Z \rightarrow l^+l^-$ is clean, and the Z+jets contribution can be predicted. This is sensitive to SUSY $\tilde{g}\tilde{g}$ production, with the gluino decay to a neutralino via $\tilde{g} \rightarrow q\tilde{q}\tilde{\chi}_2^0$, followed by $\tilde{\chi}_2^0 \rightarrow Z\tilde{\chi}_1^0$. However, the branching ratio of $\tilde{g} \rightarrow q\tilde{q}\tilde{\chi}_2^0$ is only 18% in $\mathcal{F}\text{-}SU(5)$, while the $\tilde{\chi}_2^0 \rightarrow Z\tilde{\chi}_1^0$ is a mere 0.34%. Thus, with only a 0.06% probability of a $\tilde{g} \rightarrow q\tilde{q}Z\tilde{\chi}_1^0$ transition, expectations are that this channel will experience high suppression in $\mathcal{F}\text{-}SU(5)$, and hence provide no observable SUSY signals within the 2.1 fb^{-1} data sample.

V. SIMULATION AND ERROR ANALYSIS

The explicit event selection scenarios from each of the seven CMS and ATLAS search strategies A–G discussed in the previous section are applied to a representative sampling of the viable $\mathcal{F}\text{-}SU(5)$ parameter space satisfying the bare-minimal constraints of Ref. [15]. The resulting event counts are extrapolated to the full phenomenologically viable model space for each of the seven cases, as depicted in Fig. 1. To achieve this result, we employ a detailed Monte Carlo collider-detector simulation of all 2-body SUSY processes based on the standard **MadGraph** [48, 49] suite, including the **MadEvent** [50], **PYTHIA** [51] and **PGS4** [46] chain. We employ the ATLAS and CMS detector specification cards provided with **PGS4**, and specify the cone jet clustering algorithm in all cases, with an angular scale parameter ΔR of 0.5 for CMS, and 0.4 for ATLAS. The results are filtered according to a careful replication of the individual SUSY search selection cuts, using a script **CutLHCO** of our own design [52]. SUSY particle mass calculations were performed using **MicrOMEGAs 2.1** [53], employing a proprietary modification of the **SuSpect 2.34** [54] codebase to run the *flippon*-enhanced RGEs.

An estimated uncertainty on the fitting between the simulated $\mathcal{F}\text{-}SU(5)$ event counts and the mass scale $M_{1/2}$ is computed, representing a 99% confidence level. This

narrow region of uncertainty on the $\mathcal{F}\text{-}SU(5)$ simulations, represented by the band width in Fig. 1, characterizes a combination of statistical uncertainty and variations in the vector-like *flippon* mass due to a yet unknown resolution of this M_V parameter. Although the *flippon* mass can in principle be limited to a more constrained range in order to facilitate a 124-126 GeV Higgs boson mass, we have depicted in Fig. 1 a range of uncertainty that would be inclusive of all *flippon* masses, for the sake of completeness. For reference, the nominal best $M_{1/2}$ fit to each individual study is further included. We overlay the upper and lower boundaries of uncertainty on the CMS and ATLAS derived background and data observations, displayed as rectangular shaded regions in Fig. 1. This allows us to clearly demonstrate those regions of the $\mathcal{F}\text{-}SU(5)$ model space that comply with each individual search methodology, noting estimated lower bounds on $M_{1/2}$, and in one particular case, also an upper bound on $M_{1/2}$.

We have attempted to normalize the treatment of error propagation across the various studies under consideration. In all seven cases, we are provided an uncertainty on the SM background estimate by the collaboration. In one of these cases [1], the uncertainty is carefully extracted bin-by-bin from the graphical presentation and summed in quadrature, while the remaining six reports provide direct numerical values. Whenever statistical and systematic errors are provided separately, we likewise combine these in quadrature. When given a choice between data-driven and Monte Carlo analyses, we favor the background estimate and associated (reduced) error provided by the data-driven methodology. If differential upper and lower bounds are provided, we adopt the larger of the error statistics. The central background estimates and associated $1\text{-}\sigma$ deviations are listed in the second column of Table I in Section VI for each study.

In general, the collaboration studies have not provided an explicit uncertainty on the observed data counts, but one may confidently expect Poisson statistics to apply here, and an error scaling that goes like the square root of the recorded events. Specifically, we adopt a factor of $\sqrt{(1 + \text{Data})}$ across the board, which compares satisfactorily with a graphical extraction of the event frequency bounds published in Ref. [1]. The relevant observations are summarized in the third column of Table I. Since the nominal target for SUSY event contributions is the observed excess of the recorded data over the SM background estimate, this statistical uncertainty on the event count must be combined in quadrature with the previously described uncertainty of the background estimate itself. Reassuringly, a doubling of this statistic to the $2\text{-}\sigma$ level generates a very favorable match to the 95% confidence outer bounds on SUSY counts over observed excesses that are reported in Refs.[4, 47].

Finally, any reported excess must be compared against our Monte Carlo simulation of the $\mathcal{F}\text{-}SU(5)$ model space. The statistical errors on our procedure are very small, being minimized by substantial oversampling of the in-

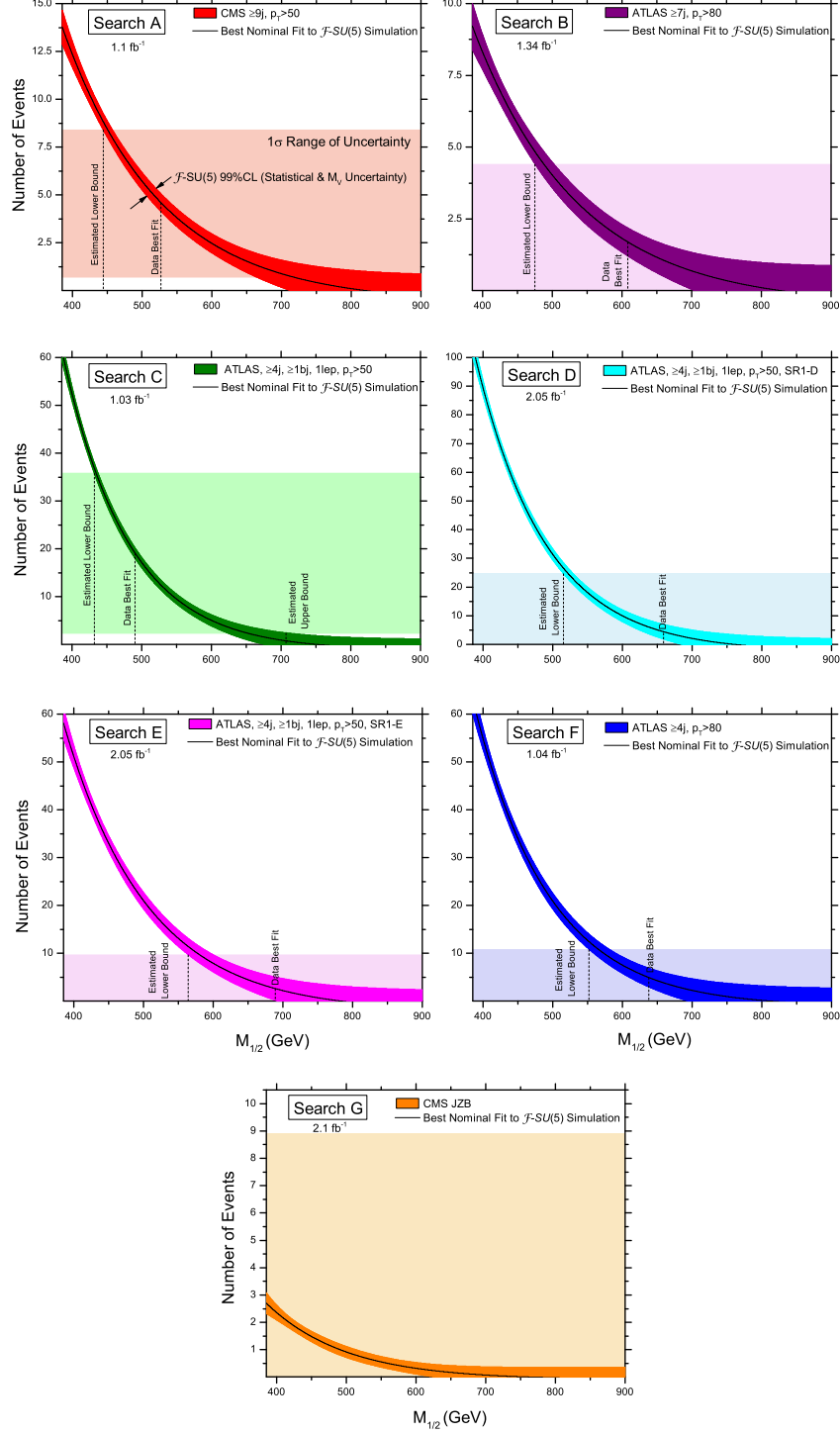


FIG. 1: Event counts for \mathcal{F} - $SU(5)$ are plotted as a function of the gaugino mass $M_{1/2}$. The span of $M_{1/2}$ in each plot space consists of the minimum $M_{1/2} = 385$ GeV and maximum $M_{1/2} = 900$ GeV allowed by application of the bare-minimal phenomenological constraints of Ref. [15]. The thickness of each curve is the consequence of a superposition of statistical uncertainty and the flexible range on the *flippon* mass M_V , where variance of M_V has a minor effect on the event counts. The median line transversing the thickness is the best nominal fit to the \mathcal{F} - $SU(5)$ event count data. The rectangular shaded regions identify the maximum and minimum number of events allowed to maintain consistency with the CMS and ATLAS reported SM background and data observations. Therefore, the intersection of the \mathcal{F} - $SU(5)$ curves with the rectangular range of uncertainty isolates the estimated upper and lower boundaries on $M_{1/2}$ in \mathcal{F} - $SU(5)$ that preserve uniformity with the CMS and ATLAS results for each individual search.

egrated luminosity. Moreover, the application of a combined full-model space fit of the expected event count against the gaugino mass $M_{1/2}$ further smoothes out statistical variations. There remains some uncertainty due to variation of the vector-like *flippon* mass scale M_V , but this higher order effect is nicely accounted for by the demonstrated width of the curves in Fig. 1, and is thus not further considered outside that context. On the other hand, the systematic errors on our procedure may be rather large, and are quite difficult to reliably estimate in a systematic manner. We have opted to employ a factor of $\sqrt{(1 + \text{Observed Excess})}$, where the observed excess that the experiments report over the expected backgrounds are tallied in the fifth column of Table I. Although this quantity is actually more naturally suited to describe the sources of statistical error than the systematic, it may still be a reasonable estimate for the systematic error, in the absence of other concrete options. Since the comparison of our simulation against the experimental results constitutes an implicit second level of subtraction, the corresponding error must again be combined in quadrature with the net experimental error on the data excess. It is this final statistic that is employed to tally the minimum and maximum permissible event count variation at the $1\text{-}\sigma$ level in columns 4 and 6 of Table I. It is also used as the denominator of our subsequent multi-axis χ^2 best fit against the seven LHC SUSY search strategies that have been outlined.

VI. THE $\mathcal{F}\text{-}SU(5)$ CORRELATIONS

Notable in Fig. 1 is the consistency which the $\mathcal{F}\text{-}SU(5)$ model enjoys with all seven search schemes, with each generally sharing a similar locally favored region of the parameter space. Excluding the highly suppressed CMS JZB search, the smallest lower bound is given by the ATLAS bjet and lepton search, at a little less than $M_{1/2} = 440$ GeV, with the ATLAS and CMS multi-jet searches also posting sub-500 GeV gaugino masses. In close proximity, the ATLAS bjet and lepton SR1-D search does however set a lower bound on $M_{1/2}$ just slightly above 500 GeV. As forecasted, the minuscule production of $q\bar{q}Z\tilde{\chi}_1^0$ does in fact mightily subdue the number of $\mathcal{F}\text{-}SU(5)$ observations in the CMS JZB cutting technique, such that no lower boundary can be ascribed to $M_{1/2}$ using the JZB tactic. Thus, it is interesting that five of the seven searches fix the lower bound on $M_{1/2}$ at about 500 GeV or less. The residual two probes, namely the ATLAS purely hadronic “High Mass” cuts and ATLAS bjet and lepton SR1-E, call for a lower limit on $M_{1/2}$ in the neighborhood of 550 GeV. Consequently, we can conclude that the $\mathcal{F}\text{-}SU(5)$ model space just above about $M_{1/2} = 550$ GeV is alive and well after application of all CMS and ATLAS $1\text{-}2\text{ fb}^{-1}$ constraints, with the model space above $M_{1/2} = 500$ GeV perfectly tolerated in five of the seven searches. Linking these $M_{1/2}$ model parameter values to experimentally vital scales, $M_{1/2} = 550$ GeV

corresponds to a light stop \tilde{t}_1 mass of about 600 GeV and a gluino \tilde{g} of about 750 GeV; $M_{1/2} = 500$ GeV correlates to a light stop of about 540 GeV and a gluino of around 690 GeV.

Six of the seven schemes require no upper bound on $M_{1/2}$ as a result of there existing no inordinate number of excess events. Nonetheless, the ATLAS bjet and lepton study does exhibit an excess even at the maximum $1\text{-}\sigma$ Standard Model limit, when applying the data-driven background statistics. The experimental collaborations at LHC are striving for data-driven backgrounds in their SUSY searches, hence we believe the choice of data-driven over Monte-Carlo generated to be justified. If this small residue is indeed substantive, then we are compelled to enforce an upper boundary on $M_{1/2}$ at about 710 GeV, which corresponds to a 785 GeV light stop mass and 970 GeV gluino mass. The interesting material result is the constitution of a narrow strip between $565 \lesssim M_{1/2} \lesssim 710$ GeV corresponding to an overlapping “Discovery Region” that is favorable for a potential finding of SUSY at ATLAS and CMS. In the upper panel of Fig. 2, we visually demonstrate this overlap by resketching those segments of the curves from Fig. 1 that maintain compatibility at $1\text{-}\sigma$ with experimental uncertainties on each search. We remark that the upper limit imposed here is somewhat provisional, pending a more substantial accumulation of collision data. In particular, the collaborations themselves maintain that the SM alone remains essentially compatible with the data, to an acceptable statistical significance. Nevertheless, the current single standard deviation limits taken at face value suggest an upper boundary for substantiation or exclusion on the $\mathcal{F}\text{-}SU(5)$ model space at about $M_{1/2} \simeq 710$ GeV ($\tilde{t}_1 \simeq 785$ GeV and $\tilde{g} \simeq 970$ GeV).

The spatial synchronicity displayed by the Discovery Region in Fig. 2 with the phenomenologically derived *Golden Strip* at $555 \leq M_{1/2} \leq 580$ GeV and *Silver Strip* at $580 \leq M_{1/2} \leq 658$ GeV is rather striking, and embodies the recurring weight of strong correlation between ostensibly independent experimental data points that we have become increasingly accustomed to observing throughout our extended study of the No-Scale $\mathcal{F}\text{-}SU(5)$ model. It is an essential prerequisite that any high-energy framework of nature discovered by precise measurements at LHC must correctly simultaneously account for the WMAP-7 measured relic density, the top quark mass and other precision electroweak parameters, and the rare-process constraints. This is a test that No-Scale $\mathcal{F}\text{-}SU(5)$ seems well poised to pass.

The SM background, data observations, and uncertainty statistics are detailed in Table I. The “Total SM” and “Data” tabulations are those reported by CMS and ATLAS. The “Signal_{Min}” and “Signal_{Max}” entries describe the $1\text{-}\sigma$ confines on the range of excess SUSY events, as shown in Fig. 1. We further display in this table nine markers of the expected event count in terms of $M_{1/2}$ to numerically illustrate the relevant progression through the region of interest. Those entries high-

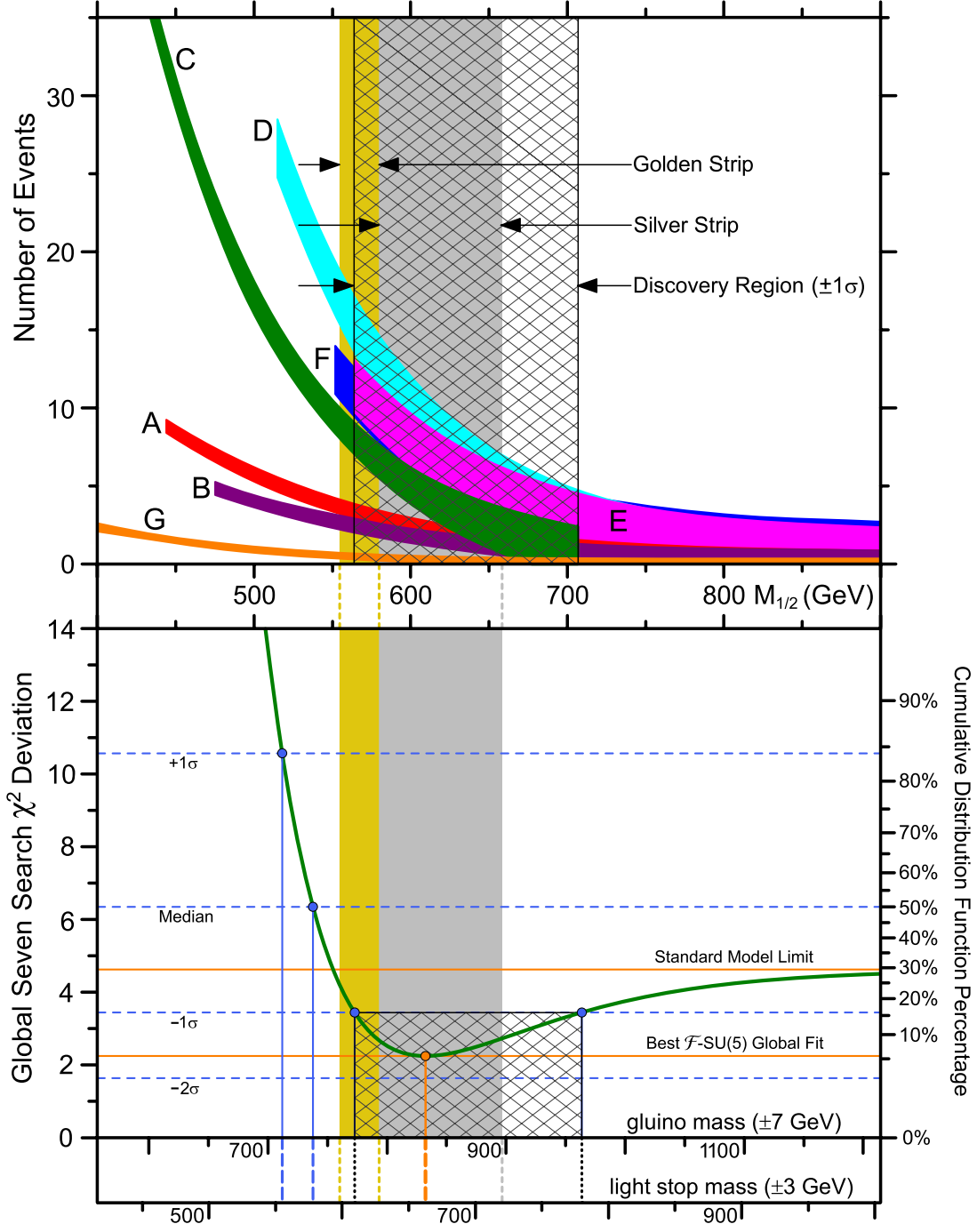


FIG. 2: In the upper panel, we superimpose event counts for the seven search methodologies studied in this work, labeling the $1\text{-}\sigma$ overlap between these strategies as the “Discovery Region”. The lower panel depicts a multi-axis χ^2 fit to the same set of seven search strategies, where the cumulative distribution function percentage demarcated on the right-hand axis dips to a minimum of 5.5% for the best overall fit at $M_{1/2} = 610$ GeV. The range of the parameter space that provides a better fit than the median at $1\text{-}\sigma$ significance is in broad agreement with the previously noted Discovery Region, and both notably intersect with the phenomenologically favored *Golden Strip* and *Silver Strip* regions. The light stop and gluino masses (in GeV) corresponding to each $M_{1/2}$ value have been inserted onto the lower horizontal axes. Uncertainties of a few GeV exist in the mapping of the axis labels for both cases, due to higher order fluctuations arising from variation in the top quark mass m_t and *flippin* mass M_V .

lighted in green depict consistency with the allowed range of uncertainty. For the ranges displayed in Table I, those points in the vicinity of $M_{1/2} = 600$ –650 GeV are best capable of simultaneously satisfying all seven LHC search strategies. Note that the width of the Discovery Region in Fig. 2 is somewhat wider than this boundary, due to the thickness of the fitting to event counts. Five benchmark spectra are listed in Table II by their model parameters, along with those supersymmetric particle masses directly relevant to our discussion. The presented benchmarks are chosen specifically to highlight the nominal best fits to various SUSY search strategies from Section IV. Specifically note the Higgs boson masses near 125 GeV for each, in tandem with the light stop and gluino.

VII. A MULTI-AXIS χ^2 FIT

We have implemented a χ^2 test in order to establish the optimal correspondence between the No-Scale \mathcal{F} - $SU(5)$ model space and the ongoing LHC SUSY search, and also to gauge the overall statistical significance of the resulting best fit. To facilitate this task, it was necessary to first establish a continuous functional relationship between the gaugino mass $M_{1/2}$ and the expected event count for each SUSY search strategy under consideration. It should be noted that this process is greatly simplified, and the result thereby lent much greater parsimony, by the fact that the spectrum is generated at leading order by only the single mass parameter. To proceed, we generously sampled the \mathcal{F} - $SU(5)$ model space at nineteen representative benchmark combinations of $(M_{1/2}, M_V, m_t \text{ and } \tan\beta)$, generating a detailed Monte Carlo collider-detector simulation, including the careful application of relevant selection cuts, as described in Section V. For each search strategy, a satisfactory continuous empirical fit was obtained by linear regression at quadratic order to the log-log distribution of event counts vs. $M_{1/2}$.

The χ^2 test statistic, which is expected to asymptotically approach the formal χ_N^2 distribution, is defined as

$$\chi^2(M_{1/2}) = \sum_{i=1}^N \left\{ \frac{(\text{Events}(M_{1/2})_i - \text{Excess}_i)^2}{\sigma_i^2} \right\} \quad (1)$$

where $\text{Events}(M_{1/2})_i$ is the continuous fit to the number of SUSY events expected from \mathcal{F} - $SU(5)$ at the given mass scale, Excess_i is the observed excess from Table I and σ_i^2 is the square of the single standard deviation error described in Section VI, all under the i^{th} set of selection cuts, with $N = 7$. The resulting function is plotted in the lower panel of Fig. 2, demonstrating a distinct minimum in the vicinity of $M_{1/2} = 610$ GeV, corresponding to light stop and gluino masses of approximately 665 GeV and 830 GeV. The significance of the fit is established by comparison with the formal χ_N^2 probability distribution with N degrees of freedom, which establishes the likelihood of a given value for the χ^2 test statistic under

application of the “null hypothesis”, *i.e.* where all signal deviations from the observed excess are attributed to uncorrelated Gaussian fluctuations about the σ_i .

The figure of merit is the cumulative distribution function (CDF) of χ_N^2 , which indicates the fraction of randomized trials under action of the null hypothesis that should be expected to produce a lower value (better fit) of the χ^2 test statistic than some given threshold value. The median value of the CDF for $N = 7$ is 6.35, and the double-sided $\pm 1, 2\sigma$ CDF values, corresponding to the traditional Gaussian percentage thresholds of 2.28%, 15.87%, 84.13% and 97.73% (centrally encapsulating 68% and 95%), fall at $\chi^2 = (1.64, 3.44, 10.57 \text{ and } 16.27)$, respectively. The best fit value of $M_{1/2}$ produces a rather small χ^2 of 2.24, corresponding to a CDF of 5.5%, immediately on the cusp of the range generally considered to represent a statistically significant deviation from the null hypothesis. The fit produced in the SM limit, the asymptote of the soft high-mass boundary in the lower panel of Fig. 2, is also reasonably satisfactory, with $\chi^2 = 4.62$, and a CDF of 29.4%. Models disfavored for overproduction at the 2- and 1- σ limits have mass scales $M_{1/2}$ of 501 GeV and 518 GeV, respectively, while the median fit occurs at 538 GeV. Models favored by a negative deviation of one standard deviation or more in the CDF exist within the range from $M_{1/2} = 564$ GeV to $M_{1/2} = 709$ GeV, with the best fit, again, around $M_{1/2} = 610$ GeV.

VIII. THE ONCE AND FUTURE LHC

We close our analysis with a brief glance in postscript toward the future $\sqrt{s} = 8$ TeV beam energy and 15 fb^{-1} of data expected in 2012, as well as the already collected 5 fb^{-1} at $\sqrt{s} = 7$ TeV that remains to be reported. If the results presented in our study in fact represent persistent correlations in the data, and not merely statistical fluctuations, then evidence of their verity should continue to ripen. The “Observed Excess” in Table I exemplifies the slender corridor with which we are attempting to extricate a signal of supersymmetry’s presence in the data. All excesses but one are less than five events, making precise extrapolations tenuous. Moreover, the subtraction of large numbers (the net event count and the expected SM background) to yield a small differential implies rather large proportional uncertainties, pushing the statistical machinery to extremes. This is a key reason that the SM asymptote maintains a reasonably favorable χ^2 value in Fig. 2.

Although (or because) we remain in a fledgling phase of the LHC data collection mission, and the status of plausible signal candidates is still tentative, this is also a period of incredibly rapid and dynamic development at the high energy and high intensity frontiers. Firstly, the fact that the beam quality is still being tuned means that the time integrated luminosity continues to grow much more rapidly than a linear trend. Secondly, since the doubling interval for data collection is still somewhat

TABLE I: A comparison of the \mathcal{F} - $SU(5)$ event counts for each of the seven search strategies discussed in Section IV. The “Total SM” and “Data” columns display the reported SM background and data observations by the CMS and ATLAS Collaborations, with the “Observed Excess” column being the difference between the nominal values of the SM and data. The “Signal_{Min}” and “Signal_{Max}” values are the minimum and maximum allowed event counts in order to be consistent with the background and observations, where the error analysis determination is elaborated in Section V. The “ $M_{1/2}$ ” columns (in GeV) contain the \mathcal{F} - $SU(5)$ event counts for each of the $M_{1/2}$ given, for a mass range chosen to represent those regions of the parameter space consistent with the LHC searches under study. The highlighted event counts are those that conform to the stated range within the “Signal_{Min}” and “Signal_{Max}” upper and lower boundaries.

						$M_{1/2}$									
Search	Total SM	Data	Signal _{Min}	Observed Excess	Signal _{Max}	475	500	525	550	575	600	625	650	675	
A	3.4 ± 0.7	8	0.7	4.6	8.4	6.9	5.7	4.7	3.8	3.1	2.5	2.0	1.5	1.2	
B	1.3 ± 0.9	3	0.0	1.7	4.4	4.8	4.0	3.3	2.7	2.2	1.8	1.5	1.2	0.9	
C	54.9 ± 13.6	74	2.4	19.1	35.8	22.7	17.1	12.8	9.5	7.0	5.0	3.6	2.4	1.6	
D	77.0 ± 18.4	81	0.0	4.0	24.7	40.9	31.3	23.8	18.0	13.5	10.0	7.2	5.1	3.4	
E	14.4 ± 5.4	17	0.0	2.6	9.7	26.3	21.0	16.6	13.1	10.2	7.9	6.0	4.5	3.2	
F	13.1 ± 3.1	18	0.0	4.9	10.8	26.6	20.9	16.3	12.7	9.8	7.5	5.7	4.3	3.1	
G	7.0 ± 2.6	11	0.0	4.0	8.9	1.2	0.9	0.7	0.6	0.4	0.3	0.2	0.2	0.1	

TABLE II: Higgs boson and sparticle masses (in GeV) are given for five benchmark gaugino masses $M_{1/2}$, representative of a best fit for each search methodology examined in this work. The light stop \tilde{t}_1 and gluino \tilde{g} columns have been highlighted to reflect their discovery mass ranges, all of which should be accessible at the $\sqrt{s} = 8$ TeV LHC in 2012, whereas the lighter points may have already been substantively probed by the $\sqrt{s} = 7$ TeV LHC during the 2011 run. The $M_{1/2} = 518$ GeV point is the representative benchmark of Ref. [20]. The $M_{1/2} = 610$ GeV point is also indicative of the precise minimum of the multi-axis χ^2 fit described in Section VII. Significantly each of the five benchmarks cataloged here can moreover handily generate a 124-126 GeV Higgs mass.

Search	$M_{1/2}$	M_V	m_t	$\tan\beta$	$\tilde{\chi}_1^0$	Higgs	$\tilde{\chi}_2^0$	$\tilde{\chi}_1^\pm$	\tilde{t}_1	\tilde{g}	\tilde{b}_1	\tilde{t}_2	\tilde{b}_2	\tilde{u}_R	\tilde{d}_R	\tilde{u}_L	\tilde{d}_L
A	518	1640	174.4	20.65	99	125.4	216	216	558	704	934	982	1046	1053	1094	1144	1147
B	610	2500	174.3	21.44	121	124.4	260	260	669	826	1076	1117	1194	1207	1252	1312	1314
C	485	1475	174.3	20.40	92	125.5	200	200	518	661	881	932	989	994	1034	1080	1083
D, E	675	2950	174.4	21.87	136	124.6	291	291	746	910	1179	1215	1301	1318	1367	1433	1435
F	638	2505	174.4	21.63	127	124.9	273	273	703	861	1123	1161	1243	1258	1305	1367	1369

low, newly accumulated statistics make extremely strong fractional contributions to the combined knowledge over reasonable time scales. A growth of the excess to a minimum of ten events will assist in sharpening the analysis to a degree, and we suspect that a full analysis of the 2012 statistics should put us well on the way toward a conclusive resolution to the matter. Thirdly, the shortly anticipated upgrade to a $\sqrt{s} = 8$ TeV beam will substantially enhance the expected SUSY event cross-sections; our Monte Carlo simulations attribute an improved time efficiency in the collection of productive data on the order of two to this upgrade.

Table III reports the extrapolated signal significance at 5 fb^{-1} for $\sqrt{s} = 7$ TeV, computed as the ratio $S/\sqrt{B+1}$ of signal events S to the square root of one plus the expected background B , for each of the seven considered SUSY searches A–G, assuming viability of the central χ^2 fit at $M_{1/2} = 610$ GeV. The “discovery index” (DI) calculates the required scaling on luminosity, reported in inverse femtobarns, that would be required to establish a nominal signal significance of five. Also shown is the signal significance at 15 fb^{-1} for $\sqrt{s} = 8$ TeV, summed with the statistics for 5 fb^{-1} for $\sqrt{s} = 7$ TeV, for a total of 20 fb^{-1} . We see that four of the seven searches exceed

the gold standard of 5.0 for signal significance for the total collected luminosity of 20 fb^{-1} expected by the close of 2012.

IX. CONCLUSIONS

No conclusive indication of supersymmetry (SUSY) has been observed at the early LHC as the accumulation of data advances toward 5 fb^{-1} , yet could enticing clues be germinating in the massive collection of observations? This is the challenging question that presently attracts our interest, and which we may currently attempt to address only by leaning upon the limited $1\text{--}2 \text{ fb}^{-1}$ of integrated luminosity amassed thus far. Although we cannot argue for incontrovertible evidence of SUSY peeping beyond the Standard Model veil, we can safely suggest that No-Scale \mathcal{F} - $SU(5)$ is a better global fit to the data than the SM alone, and moreover that its predictions appear to be meaningfully correlated with observed low-statistics excesses across a wide variety of specialized search strategies, while gracefully avoiding devastating overproduction where events are not observed. This is a strong statement in an era when the portion of phe-

TABLE III: The extrapolated signal significance $S/\sqrt{B+1}$ at 5 fb^{-1} for $\sqrt{s} = 7 \text{ TeV}$ is presented for each of the seven considered SUSY searches A–G, for $M_{1/2} = 610 \text{ GeV}$. The “discovery index” (DI) calculates the required scaling on luminosity, reported in inverse femtobarns, that would be required to establish a nominal signal significance of five. Also shown is the signal significance at 15 fb^{-1} for $\sqrt{s} = 8 \text{ TeV}$, summed with the statistics for 5 fb^{-1} for $\sqrt{s} = 7 \text{ TeV}$, for a total of 20 fb^{-1} .

Search	5 fb ⁻¹ @ 7 TeV			7 TeV	15 fb ⁻¹ @ 8 TeV		5 fb ⁻¹ @ 7 TeV + 15 fb ⁻¹ @ 8 TeV
	$\mathcal{F} - SU(5)$	SM	$S/\sqrt{B+1}$	DI (fb ⁻¹)	$\mathcal{F} - SU(5)$	SM	$S/\sqrt{B+1}$
A	8.2	15.5	2.0	29	57	107	5.8
B	4.5	4.9	1.9	31	31	34	5.7
C	15.5	267	0.9	139	107	1842	2.7
D	16.3	188	1.2	88	113	1297	3.3
E	12.9	35	2.2	26	89	242	6.1
F	24.0	63	3.0	13.8	166	435	8.5
G	0.17	16.0	0.1	69, 204	1.2	110	0.1

nomenologically viable MSSM and mSUGRA constructions is diminishing rapidly, choked out by inconsistency with the Higgs measurements and advancing squark and gluino exclusion limits.

The No-Scale $\mathcal{F} - SU(5)$ model, by virtue of its distinctive supersymmetric mass hierarchy of $M(\tilde{t}_1) < M(\tilde{g}) < M(\tilde{q})$, possesses the signature event fingerprint of a very high multiplicity of hadronic jets. Moreover, the light stop and gluino masses, possibly within reach of data collected during the $\sqrt{s} = 7 \text{ TeV}$ LHC run, renders presently maturing searches aimed at stops and gluinos quite pertinent to the testing of $\mathcal{F} - SU(5)$ as well. Building upon a prior analysis of two existing searches conducted by CMS and ATLAS, we studied five additional CMS and ATLAS search strategies, variously employing cuts on jets, b-jets and leptons, designed to reveal light stop, gluino, and squark production. A number of interesting conclusions were established.

Notably, we found that the entire region of the model space for $M_{1/2} \gtrsim 440 \text{ GeV}$ ($m_{\tilde{t}_1} \gtrsim 460 \text{ GeV}$ and $m_{\tilde{g}} \gtrsim 600 \text{ GeV}$) thrives in at least one of the seven search methodologies. When all seven searches are combined, a lower bound of $M_{1/2} \gtrsim 565 \text{ GeV}$ ($m_{\tilde{t}_1} \gtrsim 615 \text{ GeV}$ and $m_{\tilde{g}} \gtrsim 770 \text{ GeV}$) can be tentatively set. Also intriguing is the potential for one experiment, the ATLAS search requiring at least one b-jet and exactly one lepton, to demand an *upper* bound of $M_{1/2} \lesssim 710 \text{ GeV}$ ($m_{\tilde{t}_1} \lesssim 785 \text{ GeV}$ and $m_{\tilde{g}} \lesssim 970 \text{ GeV}$). However, it should be mentioned that more recent ATLAS results (also included in the present study) on similar, though not identical, selection cuts do alleviate the need to mandate an upper bound on $M_{1/2}$. The values of $M_{1/2}$ which are compatible with all search strategies under present consideration in the $1\text{-}\sigma$ overlap exist within the range of $565 \lesssim M_{1/2} \lesssim 710 \text{ GeV}$, which we refer to as the Discovery Region. In order to test the statistical significance of any correlations across the simulated $\mathcal{F} - SU(5)$ collider response in these seven search strategies, we implemented a multi-axis χ^2 fitting procedure. The best overall match was obtained in the vicinity of $M_{1/2} = 610 \text{ GeV}$ (corresponding to light stop and gluino masses of approximately 665 GeV and 830 GeV), where the χ^2_N cumulative distribution function

in seven parameters was reduced to 5.5%. The range of masses having a better fit than the median at $1\text{-}\sigma$ significance is 564–709 GeV, which is in excellent agreement with the simpler overlap statistic just reported.

Both mechanisms produce a conspicuous overlap with the highly phenomenologically favorable *Golden Strip* and *Silver Strip*, which add good agreement with rare process constraints on flavor changing neutral currents and the anomalous magnetic moment of the muon to the broader capacity of the model for respecting the WMAP7 relic density, the world average top-quark mass, radiative electroweak symmetry breaking, precision LEP Higgs and SUSY constraints, and the dynamically established boundary conditions of No-Scale supergravity. No less propitious is the ability to handily generate a 125 GeV Higgs boson mass through additional loop process contributions from the vector-like *flippon* multiplets, producing a fine accord with the statistical excesses recently reported by CMS and ATLAS in the mass range of 124–126 GeV.

The damage exacted onto the supersymmetric model landscape by the swiftly progressing LHC constraints has been severe. The tension between the growing likelihood of a 125 GeV Higgs boson mass, developing CMS and ATLAS exclusion zones, and a supersymmetric spectrum light enough to be within reach of the current operational phase of the LHC has greatly altered the conventional wisdom as to how a discovery of supersymmetry would manifest at the LHC. While the validation prospects for almost all prospective models has greatly withered, the outlook for $\mathcal{F} - SU(5)$ appears to have in fact brightened; in stark contrast, it is perfectly capable of simultaneously striking each of these three targets. A rare feat nowadays, indeed.

Acknowledgments

This research was supported in part by the DOE grant DE-FG03-95-Er-40917 (TL and DVN), by the National Science Foundation of China under grant numbers 10821504 and 11075194 (TL), by the Mitchell-Heep Chair

in High Energy Physics (JAM), and by the Sam Houston State University 2011 Enhancement Research Grant pro-

gram (JWW). We also thank Sam Houston State University for providing high performance computing resources.

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